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Hakija Applicant	NOKIA TELECOMMUNICATIONS OY Helsinki
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"IP mobility mechanism for a packet radio network"
(IP-liikkuvuusmekanismi pakettiradioverkkoa varten)

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Osoite: Arkadiankatu 6 A
Address: P.O.Box 1160
FIN-00101 Helsinki, FINLAND

Puhelin: 09 6939 500
Telephone: + 358 9 6939 500

Telefax: 09 6939 5204
Telefax: + 358 9 6939 5204

IP mobility mechanism for a packet radio network

Background of the invention

The invention relates to a mechanism for providing mobility for an Internet-type protocol in a packet radio network such as GPRS or UMTS. An example of such an Internet-type mobility protocol is the IP mobility (IP=Internet Protocol), which is the topic of standards RFC2002 to RFC2004 and RFC2290 by the Internet Engineering Task Force (IETF). These RFC standards are incorporated herein by reference. In short, IP mobility is a mechanism for providing a mobile user with telecommunications capability using an IP address. It enables mobile nodes to change their points of attachment in the Internet without changing their IP address. Thus it facilitates the communication of a mobile node and a correspondent host with the mobile node's home address. Fig. 1 illustrates some elements of a packet radio network which are relevant to the invention.

Within the context of this application 'Network Access Server (NAS)' is a device providing users with temporary, on-demand network access. This access is point-to-point using telephone, ISDN or cellular connections, etc. 'Mobile Node (MN)' refers to a host that wishes to use a Home Network address while physically connected by a point-to-point link (phone line, ISDN, etc.) to a NAS that does not reside on the Home Network. 'Mobile Station (MS)' is a mobile node having a radio interface to the network. A 'Tunnel' is the path followed by a datagram when it is encapsulated. The model is that, while it is encapsulated, a datagram is routed to a known decapsulation agent, which decapsulates the datagram and then correctly delivers it to its ultimate destination. Each mobile node connecting to a home agent does so over a unique tunnel, identified by a tunnel identifier which is unique to a given Foreign Agent/Home Agent pair.

'Home Network' is the IP network to which a user logically belongs. Physically, it can be e.g. a local area network (LAN) connected via a router to the Internet. 'Home Address' is an address that is assigned to a mobile node for an extended period of time. It may remain unchanged regardless of where the MN is attached to the Internet. Alternatively, it could be assigned from a pool of addresses. 'Home Agent' is a routing entity on a mobile node's home network which tunnels packets for delivery to the mobile node when it is away from home, and maintains current location information for the mobile node. It

tunnels datagrams for delivery to, and, optionally, detunnels datagrams from, a mobile node when the mobile node is away from home.

'Foreign Agent' refers to a routing entity on a mobile node's visited network which provides routing services to the mobile node while registered, thus allowing a mobile node to utilise its home network address. The foreign agent detunnels and delivers packets to the mobile node that were tunnelled by the mobile node's home agent. For datagrams sent by a mobile node, the foreign agent may serve as a default router for registered mobile nodes.

RFC2002 defines 'Care-of Address' (COA) as the termination point of a tunnel toward a mobile node, for datagrams forwarded to the mobile node while it is away from home. The protocol can use two different types of care-of address: a "foreign agent care-of address" is an address announced by a foreign agent with which the mobile node is registered, and a "co-located care-of address" is an externally obtained local address which the mobile node has acquired in the network. Within the context of this application, 'Care-of Address' (COA) is an announced address of a foreign agent with which the mobile node is registered. An MN may have several COAs at the same time. An MN's COA is registered with its HA. The list of COAs is updated when the mobile node receives advertisements from foreign agents. If an advertisement expires, its entry or entries should be deleted from the list. One foreign agent can provide more than one COA in its advertisements. 'Mobility Binding' is the association of a home address with a care-of address, along with the remaining lifetime of that association. An MN registers its COA with its HA by sending a Registration Request. The HA replies with a Registration Reply and retains a binding for the MN.

Routing data packets to an MN is a problem in a packet radio network, such as GPRS. This is because the MN's data network address typically has a static routing mechanism, whereas a MN can roam from one subnetwork to another. One approach for data packet routing in a mobile environment is the concept of Mobile IP. Mobile IP enables the routing of IP datagrams to mobile hosts, independent of the point of attachment in the subnetwork. The standard Mobile IP concept does not fit exactly in the GPRS environment because network protocols other than IP must be supported too. Also, mobility management within a GPRS network is based on mechanisms different from Mobile IP, which is only defined for the Internet Protocol.

The GPRS infrastructure comprises support nodes such as a GPRS gateway support node (GGSN) and a GPRS serving support node (SGSN). The main functions of the GGSN nodes involve interaction with the external data network. The GGSN updates the location directory using routing information supplied by the SGSNs about an MS's path and routes the external data network protocol packet encapsulated over the GPRS backbone to the SGSN currently serving the MS. It also decapsulates and forwards external data network packets to the appropriate data network and handles the billing of data traffic.

The main functions of the SGSN are to detect new GPRS mobile stations in its service area, handle the process of registering the new MSs along with the GPRS registers, send/receive data packets to/from the GPRS MS, and keep a record of the location of the MSs inside of its service area. The subscription information is stored in a GPRS register (HLR) where the mapping between a mobile's identity (such as MS-ISDN or IMSI) and the PSPDN address is stored. The GPRS register acts as a database from which the SGSNs can ask whether a new MS in its area is allowed to join the GPRS network.

The GPRS gateway support nodes GGSN connect an operator's GPRS network to external systems, such as other operators' GPRS systems, data networks 11, such as an IP network (Internet) or a X.25 network, and service centres. Fixed hosts 14 can be connected to data network 11 e.g. by means of a local area network LAN and a router 15. A border gateway BG provides an access to an inter-operator GPRS backbone network 12. The GGSN may also be connected directly to a private corporate network or a host. The GGSN includes GPRS subscribers' PDP addresses and routing information, i.e. SGSN addresses. Routing information is used for tunnelling protocol data units PDU from data network 11 to the current switching point of the MS, i.e. to the serving SGSN. The functionalities of the SGSN and GGSN can be connected to the same physical node.

The home location register HLR of the GSM network contains GPRS subscriber data and routing information and it maps the subscriber's IMSI into one or more pairs of the PDP type and PDP address. The HLR also maps each PDP type and PDP address pair into a GGSN node. The SGSN has a Gr interface to the HLR (a direct signalling connection or via an internal

backbone network 13). The HLR of a roaming MS and its serving SGSN may be in different mobile communication networks.

The intra-operator backbone network 13, which interconnects an operator's SGSN and GGSN equipment can be implemented, for example, by means of a local network, such as an IP network. It should be noted that an operator's GPRS network can also be implemented without the intra-operator backbone network, e.g. by providing all features in one computer.

A GPRS network in its current form is able to support IP mobility if a MS implements the Mobile IP protocol and if it has a private IP address assigned by some company or Internet service provider (ISP). When a GGSN node assigns a temporary IP address to the MS, the MS can use this temporary address as its care-of-address (COA) and register the address with its home agent, thus benefiting from the Mobile IP services. This is also true when the MS is using a predefined GGSN IP address, which can also be regarded as a COA.

A problem of the temporary and predefined GGSN-assigned IP addresses in the known IP mobility mechanisms is that they consume valuable IPv4 address space because a MS requires two IP addresses, one from its home network and another one from the visited network. Moreover, the tunnelling requires that IP packets are sent to the MS using Mobile IP encapsulation, which wastes precious radio resources.

Disclosure of the invention

An object of the invention is to solve or at least minimise the problems associated with the prior art IP mobility mechanisms. The object is achieved with a method and equipment which are characterized by what is disclosed in the attached independent claims. Preferred embodiments of the invention are disclosed in the attached dependent claims.

The invention is based on the vision that a foreign agent is integrated or consolidated into a support node of a packet radio network. In a GPRS network, suitable support nodes are the gateway nodes (GGSN) and the access nodes (SGSN). In so-called third generation (3G) systems, the SGSN nodes are sometimes referred to as 3G-SGSN nodes. This integration or consolidation is not simple physical co-location but something more fundamental, wherein the MS can use the foreign agent's care-of-address COA.

Thus the MS will not need (consume) any additional IP addresses from the visited network.

Another advantage of the fundamental integration relates to the time-to-live field of IP datagrams. IP datagrams comprise a time-to-live field which is decremented by one when the datagram is routed by a router or tunnelled by a host (or a GGSN) to a new destination. (The time-to-live field is also called a hop count or a hop limit.) There are two mechanisms by which an MS may gain knowledge of the services offered by an FA. The FA can declare its services using advertisement messages or the MS can send inquiries called agent solicitation messages. These advertisement messages and agent solicitation messages are ordinary IP datagrams with the time-to-live field set to one. If the FA was a separate network element or simply co-located with a support node (GGSN or SGSN), the support node would have to decrement the time-to-live field to zero and then discard the datagram and generate an ICMP (Internet Control Message Protocol) error message upon reception of an agent advertisement message or agent solicitation message. Therefore the FA should be deeply integrated into the support node in a way which does not interfere with the datagrams' time-to-live calculations. In other words, the FA can be said to be integrated into the support node if the support node, which receives a datagram addressed to the FA with a time-to-live field set to one, can forward the datagram to the FA.

A further advantage of the invention is that Mobile IP support becomes a service provided by the network operator. Thus the operator can also charge the users for this service.

In order for the MS to keep the existing Mobile IP binding with its home agent, the MS has to reregister with its home agent before the connection times out. The foreign agent or SGSN/GGSN could be thought to perform the re-registration on behalf of the MS (in order to save air interface resources). This is, however, impossible because the MS authenticates the registration messages by using a secret key shared between itself and its home agent. Therefore, neither the FA nor the SGSN/GGSN can do the (re)registration on behalf of the MS, because they don't know the key.

According to a first embodiment of the invention, the foreign agent is integrated into an SGSN node. According to a second embodiment, the foreign agent is integrated into a GGSN node.

Brief description of the drawings

The invention will be described in more detail by means of preferred embodiments with reference to the appended drawing on which:

Figs. 1 and 2 are block and signalling diagrams, respectively, illustrating an IP mobility mechanism according to the first embodiment of the invention; and

Figs. 3 and 4 are block and signalling diagrams, respectively, illustrating an IP mobility mechanism according to the second embodiment of the invention.

Detailed description of the invention

Fig. 1 is block diagram illustrating an IP mobility mechanism according to the first embodiment of the invention wherein the foreign agent FA is integrated into an SGSN or a 3G SGSN, commonly referred to as an access node. The MS can be a laptop computer PC connected to a packet radio enabled cellular telephone. Alternatively, the MS can be an integrated combination of a small computer and a packet radio telephone, similar in appearance to the Nokia Communicator 9000 series. Yet further embodiments of the MS are various pagers, remote-control, surveillance and/or data-acquisition devices, etc.

The Radio Access Network RAN can be a part of a GPRS system or a third generation (3G) system, such as UMTS. The RAN comprises an air interface Um which is a performance bottleneck. Subscriber information is stored permanently in the Home Location Register HLR.

To cover the entire area of the network, foreign agents FA should be installed in every access node SGSN. Each FA has an IP address in the Internet and in the operator's own private GPRS/3G backbone network. For each access node/FA, a permanent packet data context exists in the corresponding gateway node GGSN to enable tunnelling towards the FA. One of the link protocols between a MS and the access node (e.g. Layer 3 Mobility Management, L3-MM) is modified to support IP mobility.

A reference is now made to Fig. 2. The user of a mobile station MS subscribes to a special Mobile IP service. The subscription information is stored in the Home Location Register HLR together with the user's home IP address. There is a permanent GTP tunnel between the SGSN/FA and the GGSN. This tunnel can be configured by network management. In step 2-2 the

MS attaches to the packet radio network. In step 2-4 the user of the MS is authenticated, which involves querying subscriber security information from the HLR. In step 2-6, the subscriber information indicates that the MS relates to a mobile subscriber, i.e. a Mobile IP user. The subscriber information also comprises the user's home address. Alternatively, this information could be provided by the MS in the attach request or context activation request message. After the attach procedure, in step 2-8 the MS (or its user) initiates PDP context activation for the IP protocol. In step 2-10 the SGSN/FA creates a context for the MS. The context is created on the basis of the MS's home address and its IMSI. In the PDP context activation acknowledgement message 2-12, the SGSN/FA sends the FA's IP address to the MS. The FA's IP address belongs topologically to the operator's IP network. More precisely, the FA's IP address is such that IP packets destined to that address are routed in the Internet to the GGSN that has the permanent packet data context corresponding to the FA. Having received the acknowledgement, in step 2-14 the MS initiates Mobile IP registration to its home agent HA by sending a Mobile IP Registration Request message to the SGSN/FA. The message from the MS to the FA can be sent on the LLC (Logical Link Control) or SNDCP (Subnetwork Dependent Convergence Protocol) layer. It could also be part of modified L3-MM. Inside the SGSN/FA, the message is forwarded to the FA section (involving no IP routing or time-to-live calculations between the SGSN and the FA). Next, in step 2-16, the FA relays the registration request to the HA (using e.g. UDP/IP, UDP = User Datagram Protocol). In step 2-18, the HA sends a registration reply to the FA which, in step 2-20, finally forwards it to the MS. After step 2-20, there is a Mobile IP tunnel from the SGSN/FA to the HA. If the particular implementation of Mobile IP uses reverse tunnelling, the tunnel exists also in the reverse direction.

According to the second embodiment of the invention, as shown in Fig. 3, the foreign agent FA is integrated into a GGSN, commonly referred to as a gateway node. In this case the MS uses as its COA the address of the FA in the gateway node. In order to establish mobility binding, the MS has to send additional information to the access node (SGSN). Because of this additional information, the selected gateway node knows that a received IP address is valid although it does not belong to this particular gateway node. The gateway node detects registration messages from the MS and sends them to its FA unit

for processing. Moreover, the gateway node GGSN/SGSN can accept any IP address from the MS and use the address of the FA as the MS's COA.

As a practical example of the additional information, an access point name (APN) could be used. The APN indicates the operator's name and a Mobile IP address. It is a logical name which the MS sends to the access node and which the access node in turn sends to the gateway node. The access node uses the APN to select a particular gateway node and the gateway node in turn uses it to select a particular ISP. Thus the APN is used for requesting the services of a particular gateway node.

Fig. 4 is a signalling diagram illustrating the second embodiment of the invention. Signalling steps having identical reference numbers with those in Fig. 2 have identical functions, and they will not be described again. The major difference between the embodiments shown in Figs 2 and 4 is, of course, that in Fig. 4 the FA is integrated into the GGSN instead of the SGSN. Therefore, in step 4-11, the SGSN sends an FA Query to the GGSN+FA. This query is acknowledged in step 4-11'. Steps 4-14 to 4-20 correspond to respective steps 2-14 to 2-20, but they are sent to/from GGSN, instead of the SGSN. Similarly, the Mobile IP tunnel is established from the GGSN+FA to the HA, and the implementation permitting, also in the reverse direction..

The description only illustrates preferred embodiments of the invention. The invention is not, however, limited to these examples or the terms used, but it may vary within the scope of the appended claims.

L 3

Claims

1. A method for providing Internet Protocol-type, or IP-type, mobility service for a mobile station (MS) in packet radio network comprising at least two support nodes wherein at least one support node is an access node (SGSN), and at least one support node is a gateway node (GGSN); the method being c h a r a c t e r i z e d by:

installing into said packet radio network a foreign agent (FA) having an IP address;

integrating the foreign agent (FA) into one of the support nodes (SGSN; GGSN); and

providing a care-of-address (COA) for the mobile station (MS);

using the IP address of, or provided by, the foreign agent (FA) as the mobile station's (MS) care-of-address (COA).

2. A method according to claim 1, c h a r a c t e r i z e d by integrating the foreign agent (FA) into an access node (SGSN).

3. A method according to claim 1, c h a r a c t e r i z e d by integrating the foreign agent (FA) into a gateway node (GGSN).

4. A method according to any one of the preceding claims, c h a r a c t e r i z e d by using the IP address of the foreign agent (FA) as the mobile station's (MS) care-of-address (COA).

5. A method according to claim to any one of the preceding claims, c h a r a c t e r i z e d in that the mobile station (MS), in connection with an attach procedure, sends an access point name (APN) indicating the network operator and a Mobile IP address.

6. A method according to claim 5, c h a r a c t e r i z e d in that the mobile station (MS) sends the access point name (APN) to the access node (SGSN) and the access node sends it to the gateway node (GGSN).

7. A method according to any one of the preceding claims, c h a r a c t e r i z e d in that a register of the packet radio network, preferably its Home Location Register (HLR), stores information concerning whether or not the mobile station in question or its subscriber is allowed to use said IP-type mobility service.

8. A method according to any one of the preceding claims, c h a - r a c t e r i z e d in that the mobile station (MS), preferably in connection with registering, informs the packet radio network concerning whether or not it requests the use of said IP-type mobility service.

9. An arrangement for providing IP-type mobility service for a mobile station (MS), the arrangement comprising:

at least two support nodes wherein at least one support node is an access node (SGSN), and at least one support node is a gateway node (GGSN);

the arrangement being c h a r a c t e r i z e d by:

a care-of-address (COA) for the mobile station (MS);

a foreign agent (FA) having an IP address being integrated into one of the support nodes (SGSN; GGSN); and

the IP address of the foreign agent (FA) being also the mobile station's (MS) care-of-address (COA).

10. An arrangement according to claim 9, c h a r a c t e r i z e d in that the foreign agent (FA) is integrated into one of the access nodes (SGSN).

11. An arrangement according to claim 9, c h a r a c t e r i z e d in that the foreign agent (FA) is integrated into one of the gateway nodes (GGSN).

12. A support node (GGSN, SGSN) for a packet radio network, arranged to provide mobility service for a mobile station (MS), wherein the gateway support node (GGSN+HA) supports at least IP-type protocol;

c h a r a c t e r i z e d in that the support node (GGSN, SGSN):

comprises an integrated foreign agent (FA) having an IP address; and

is adapted to use the IP address of, or provided by, the foreign agent (FA) as the mobile station's (MS) care-of-address (COA).

(57) Abstract

An arrangement for providing IP mobility for a mobile station (MS). The mobile station (MS) has a care-of-address (COA) for routing data packets when the MS is away from home. The arrangement comprises support nodes, called access nodes (SGSN), and gateway nodes (GGSN), and a foreign agent (FA) having an IP address. In order to save IP addresses and radio resources the foreign agent (FA) is integrated into one of the support nodes (SGSN) and the IP address of, or provided by, the foreign agent (FA) is also used as the mobile station's (MS) care-of-address (COA).

(Fig. 1)

1/2

Fig. 1

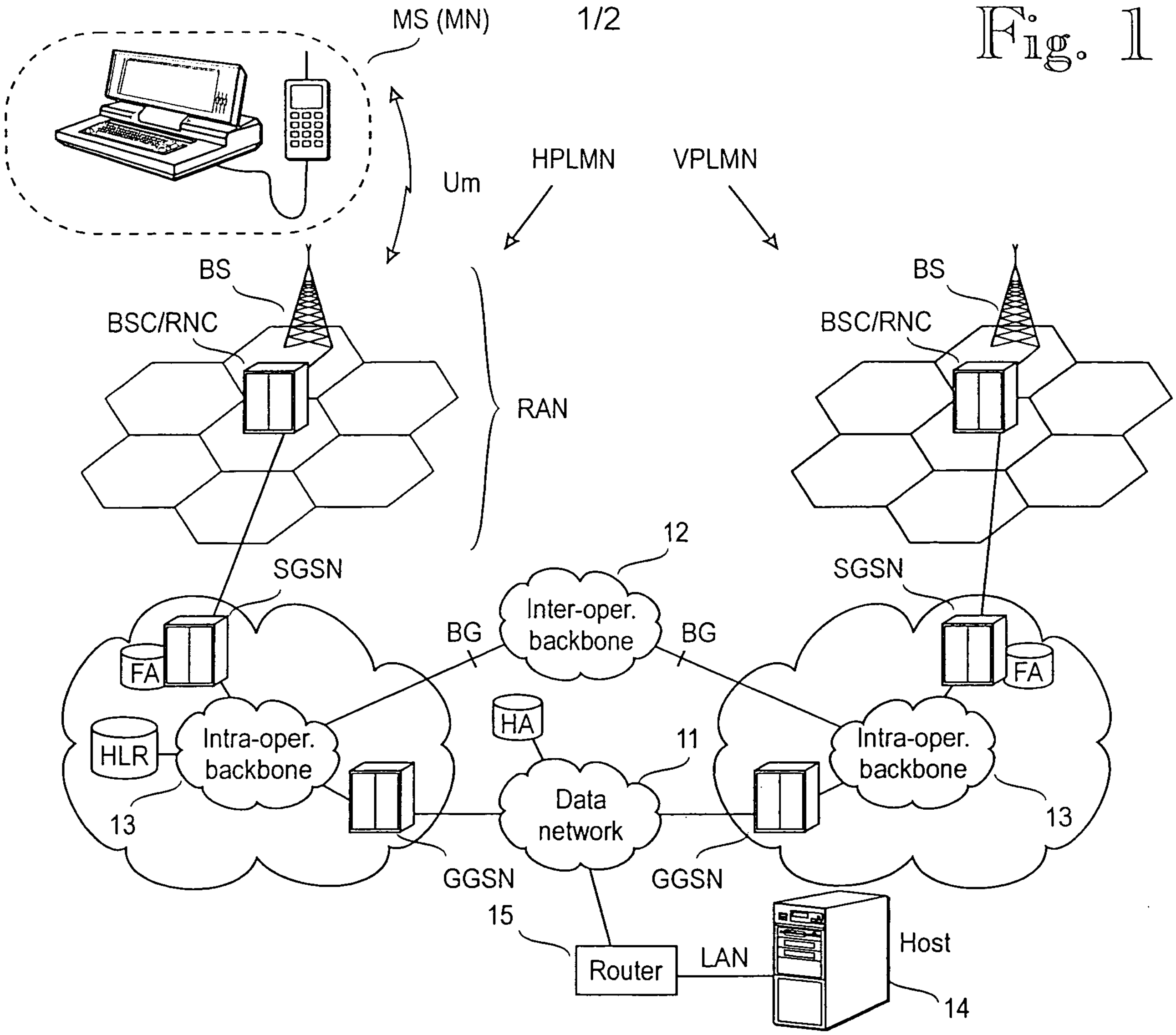

MS (MN)
Um
HPLMN
VPLMN
BS
BSC/RNC
RAN
BS
BSC/RNC
12
SGSN
Inter-oper.
backbone
BG
BG
SGSN
FA
FA
HLR
Intra-oper.
backbone
HA
11
Intra-oper.
backbone
13
Data
network
13
GGSN
GGSN
15
Host
Router
LAN
14

Fig. 3

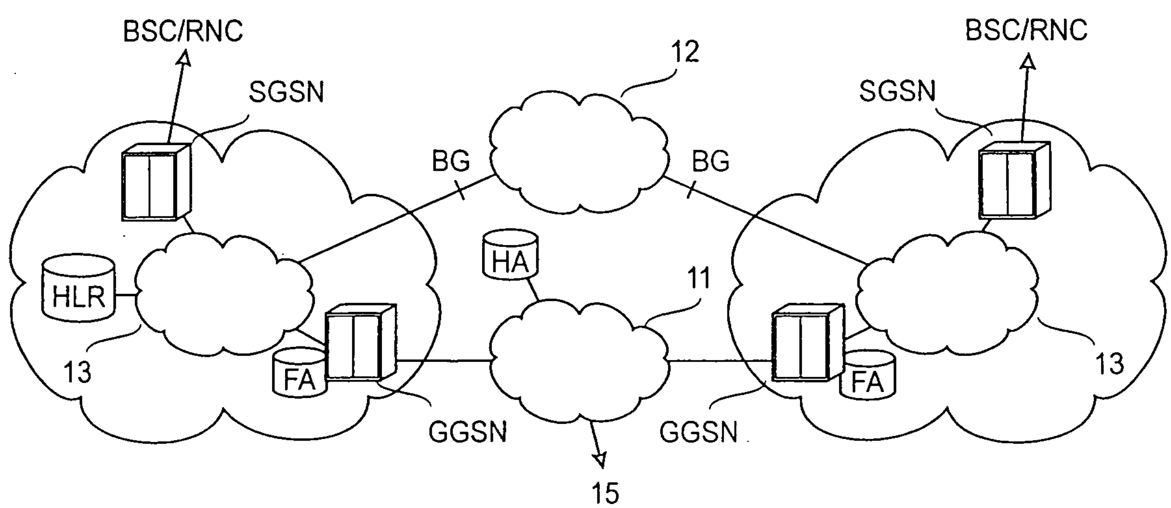

BSC/RNC
12
BSC/RNC
SGSN
SGSN
BG
BG
HA
HLR
11
13
FA
FA
13
GGSN
GGSN
15

Fig. 2

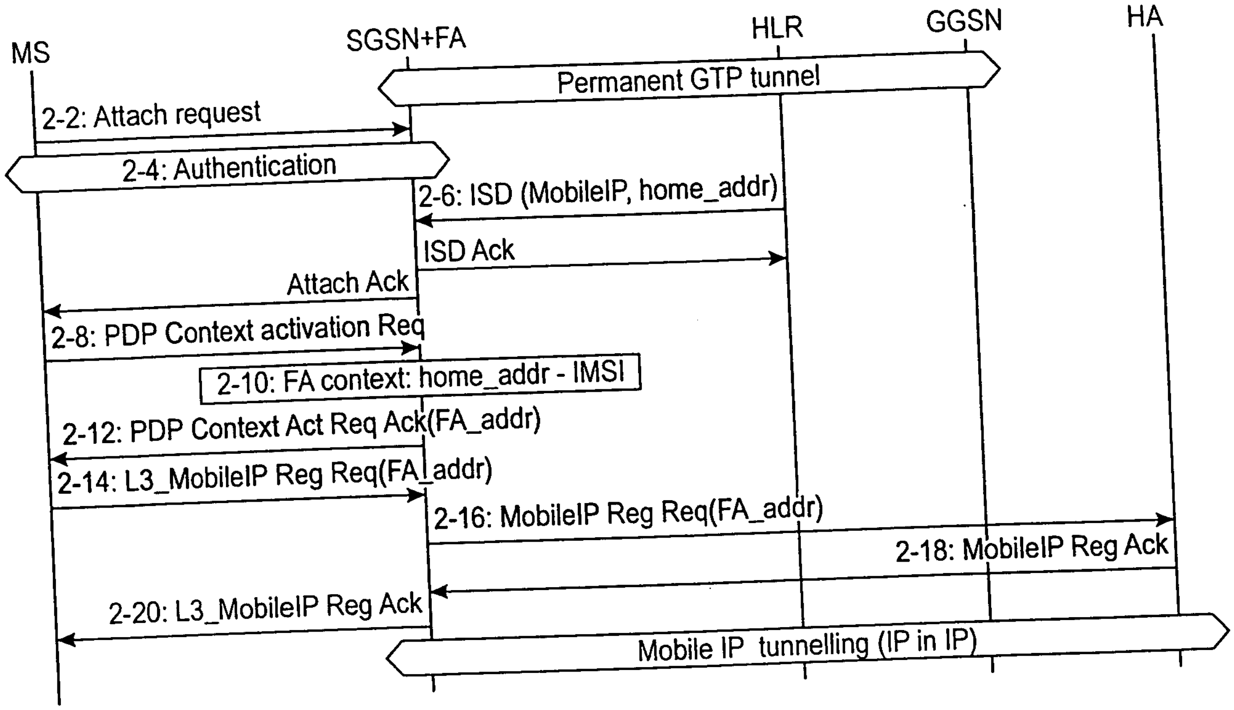
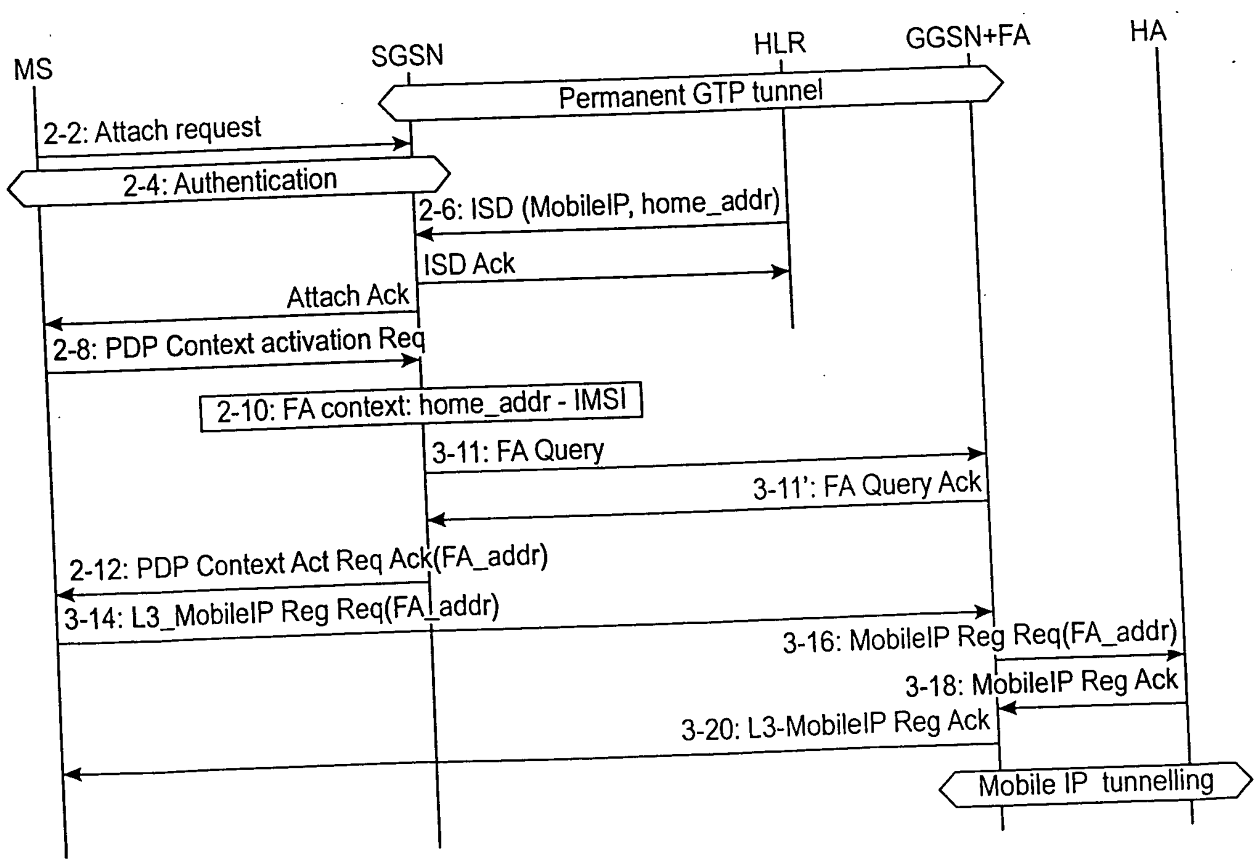

MS
SGSN+FA
HLR
GGSN
HA
Permanent GTP tunnel
2-2: Attach request
2-4: Authentication
2-6: ISD (MobileIP, home_addr)
ISD Ack
Attach Ack
2-8: PDP Context activation Req
2-10: FA context: home_addr - IMSI
2-12: PDP Context Act Req Ack(FA_addr)
2-14: L3_MobileIP Reg Req(FA_addr)
2-16: MobileIP Reg Req(FA_addr)
2-18: MobileIP Reg Ack
2-20: L3_MobileIP Reg Ack
Mobile IP tunnelling (IP in IP)

Fig. 4


MS
SGSN
HLR
GGSN+FA
HA
Permanent GTP tunnel
2-2: Attach request
2-4: Authentication
2-6: ISD (MobileIP, home_addr)
ISD Ack
Attach Ack
2-8: PDP Context activation Req
2-10: FA context: home_addr - IMSI
3-11: FA Query
3-11': FA Query Ack
2-12: PDP Context Act Req Ack(FA_addr)
3-14: L3_MobileIP Reg Req(FA_addr)
3-16: MobileIP Reg Req(FA_addr)
3-18: MobileIP Reg Ack
3-20: L3-MobileIP Reg Ack
Mobile IP tunnelling